

“Water Quality in Florida Bay”

Or a more appropriate title is:

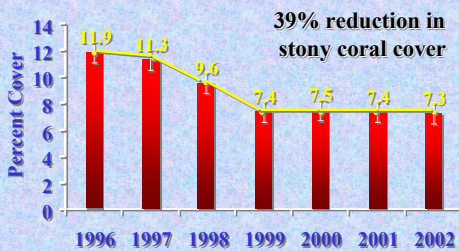
“Contributing Factors in the Decline of Coral Reefs in the Florida Keys”

Prepared by:
Dr. Brian Keller
Dr. Peter Ortner
&
Billy D. Causey

Recent Press

- Quoted a few scientists who have placed the blame for the decline of coral reefs in the Florida Keys on land-based sources of nitrogen
- Implications are agricultural and sewage sources of nitrogen
- My intent with this briefing is to point out what our water quality monitoring data shows and explain the complexity of the problems affecting coral reefs here and around the world

**Mean Percent Stony Coral Cover
Sanctuary-Wide 1996-2002**

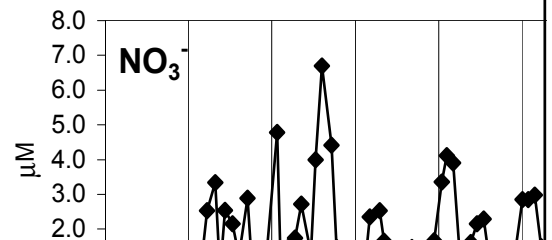


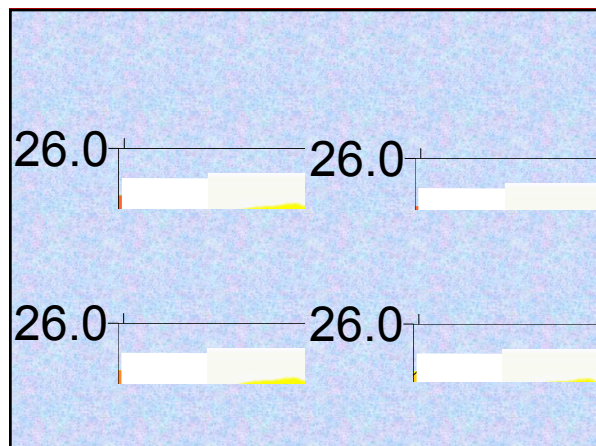
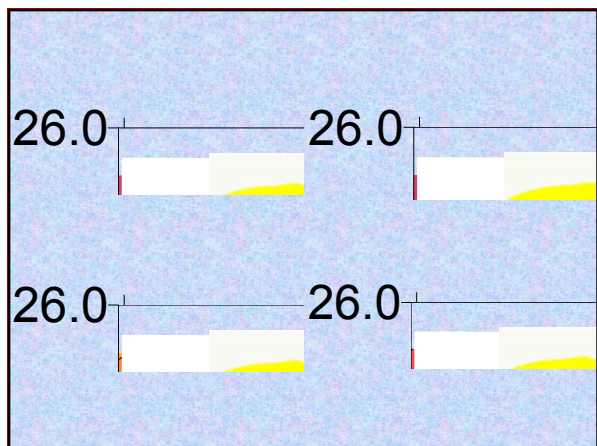
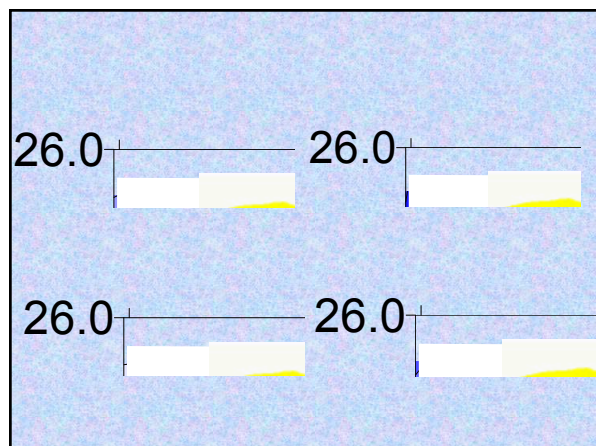
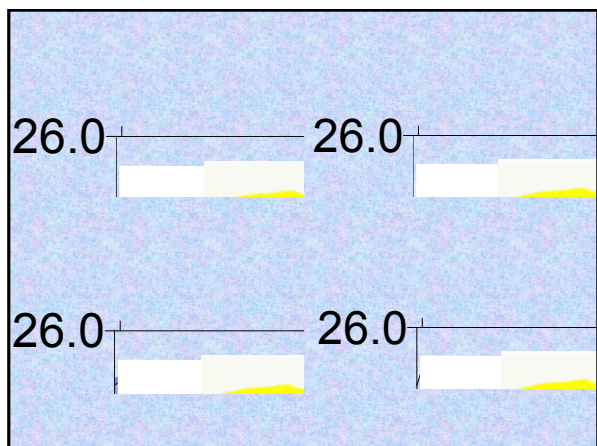
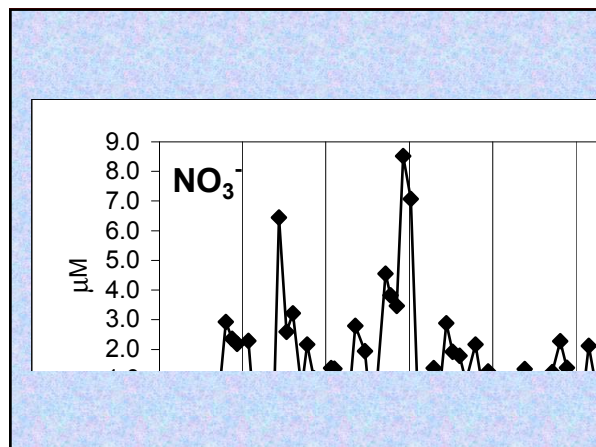
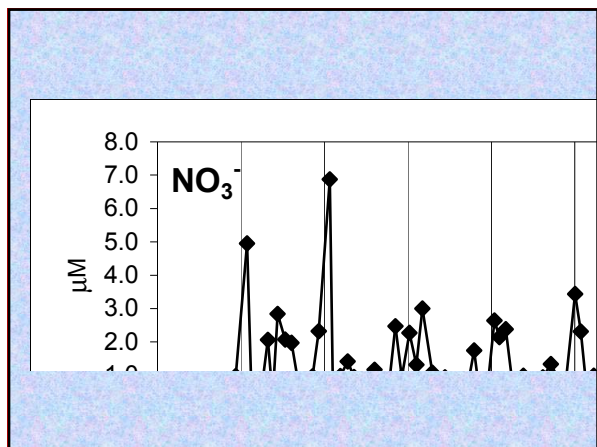
Questionable Conclusions:

- 1) **N** is moving from on-shore to off-shore.
- 2) **N** is being transported there by rainfall and coastal outwelling, not primarily by oceanic upwelling.
- 3) The $\delta^{15}\text{N}$ signal of the water and the biota is similar to Florida Keys sewage; it is not similar to upwelled material.



FIU water quality sites at the estuarine termination of Shark River Slough.





Climate Trends

Status

- 10 warmest years on record have occurred since 1983
- 7 of these since 1990
- Fastest global warming rate in 10,000 years

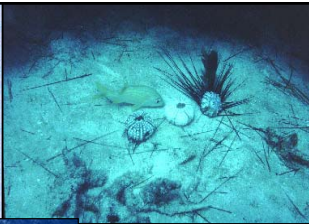


Coral Bleaching

- Intensified over the past two decades
- Seems to be synchronized around El Niño events(Peter Glynn, 1984)
- Elevated ocean temperatures
- Related secondary impacts

1983 Coral bleaching Lower Florida Keys

"From a distance, spurs looked like snow-draped ridges." ...Walt Jaap (1985)



1983 *Diadema* die-off



1987 Global coral bleaching event



1986 Black band disease Looe Key Reef

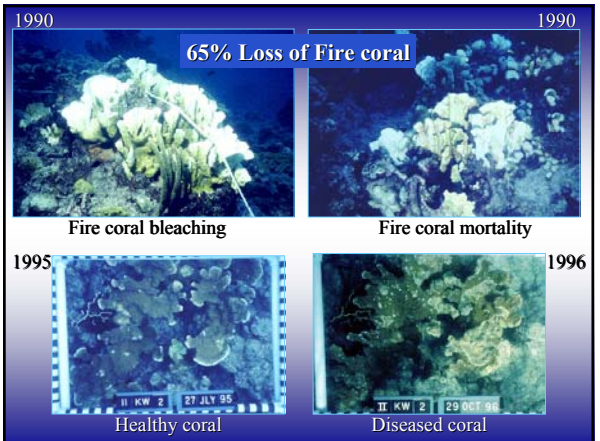
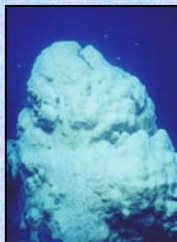


Looe Key Reef

Coral Bleaching Trends (Cont.)

1990

- Doldrum weather patterns in July
- Massive bleaching
- * Coral bleached inshore for the first time
- * Large-scale coral mortality for the first time
- * - Implemented monitoring protocol
- 65% of fire coral on some reefs
- Global bleaching event



Coral Bleaching Trends (Cont.)

1997

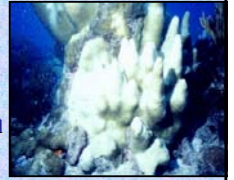
- Doldrum weather patterns
- Massive bleaching
- Inshore and offshore corals affected
- Alerts from 3rd generation Florida Keys residents
- Large loss of living corals
- Global bleaching event



Coral Bleaching Trends (Cont.)

1998

- Water remained warm from 1997
- Massive bleaching continued
- Inshore and offshore corals affected
- Continued loss of living corals
- Global bleaching event
- * First back-to-back annual coral bleaching
- Hurricane Georges



“The major coral bleaching and mortality event of late 1997 and 1998 was by far the worst on record and also the most widespread.

..... “Reefs in the 3 Oceans were affected with severe bleaching

Clive Wilkinson ... 2002

“Coral bleaching and mortality rank as probably the major threat to the reefs in the Pacific.”

Clive Wilkinson - 2002

Coral Bleaching Trends

- Local patterns of increased duration
- Patterns of geographical expansion
- Coral reefs are responding to warming trends

“Coral reefs throughout the world are currently experiencing accelerated degradation.”

.... Wilkinson (1992, 1999)

.... Sebens (1994)

- reduced coral cover
- reduced fish abundance
- reduced species diversity
- many causal factors
- coral bleaching is major agent of change





“Mass coral bleaching is currently viewed as a major threat to the long-term health of coral Reef communities.”

.... Bruno, et al (2001)

“Reasons behind current change in reef health include a complex cocktail of direct and indirect factors.”

Ove Hoegh-Guldberg (2003)



“The high likelihood that there will be increases in the climate-related frequency of sea warming events causing major coral bleaching and coral death in coming decades makes effective stewardship of coral reefs and associated habitats now more important than ever.”

..... Terry Done (2001)

Looe Key Coral Bleaching 1997-1998



Coral Reef Early Warning System (C.R.E.W.S.)

- Expert system (knowledge-based) attempts to replicate the reasoning process of experts in the field to send out alerts for bleaching
- Processes data in near real-time from in-situ instrumentation to produce early warnings of coral bleaching
- Accurately predicted a bleaching event on Great Barrier Reef (Hendee and Berkelmans 2001)
- Bleaching Alerts are based on an interaction of the following:
 - High SST
 - Low winds during mid-day
 - Low tides during mid-day
 - High illumination (PAR or UV-B) at mid-day
 - High water clarity at mid-day
 - Time of day of stressful observation
 - Duration of stressful observation

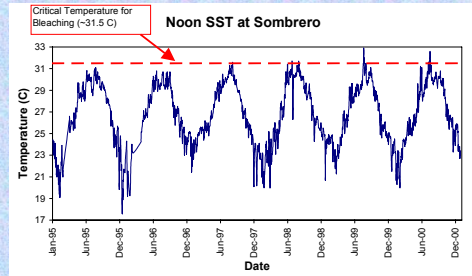
Evidence

- Peer-reviewed scientific literature generally points to **high SST and UV light as the synergistic cause of bleaching**
- **C.R.E.W.S. accurately predicted bleaching events** in 1997 & 1998 based upon only SST and estimated UV light exposure.
- Bleaching was **worldwide** in 1997-1998
- **SST** in the Looe Key area began to **cross the critical threshold** for coral bleaching in **1997-1998**
- **Discharge** at both **Shark and Caloosahatchee River** was **not inordinately high** in the summer of either 1997 or 1998
- **No high nitrogen “signal”** at Looe Key reef 1997-1998

C.R.E.W.S. Alerts in 1997-1998 from Sombrero

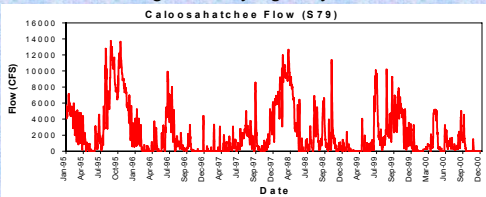
- Sent out coral bleaching alert on July 29, 1998 based on high SST
- Sent out coral bleaching alert on August 16, 1998 based on high SST, **low wind speed**, and **low tide**
- Low wind speed and low tide are used to approximate an increase in UV and light penetration to the reef
- Hind-cast the 1997 bleaching event using data from Sombrero and PAR irradiation at a nearby station
- Thus, these bleaching events were accurately predicted based on SST, **wind**, and **tide** indicating the cause was high SST, along with increased light and UV penetration

SST at Sombrero Reef

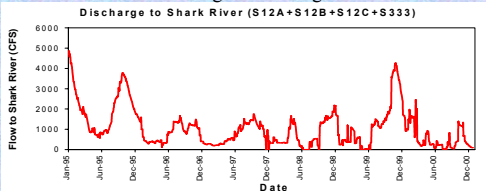


- SST approached and surpassed 31.5°C, the critical value for coral bleaching, in the late spring/early summer of 1997

Caloosahatchee discharge relatively high only in midwinter 1997-98



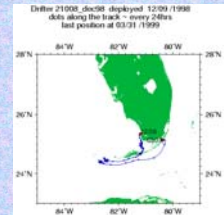
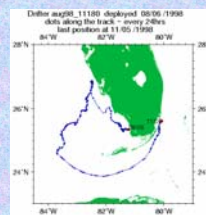
Shark River Discharge low throughout 1997-1998



Summer

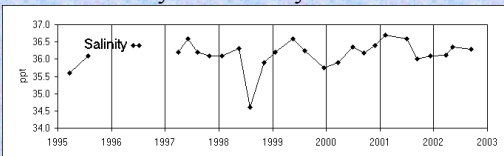
Physical Connection

Winter

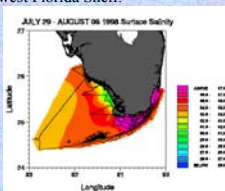


- SW Flow and western Countercurrent only in the winter
- Not coincident with summer initiation of coral bleaching
- To reach Looe Key Shark River discharge takes more than a month (longer from Caloosahatchee)
- Diatom blooms on the SW Shelf tend to be N limited and exhaust available nitrogen quickly (Jurado 2003)

Salinity at Looe Key from SERC

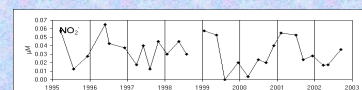
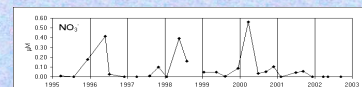
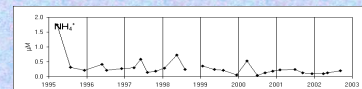
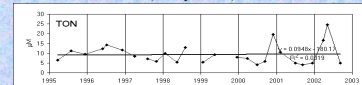


The only lower salinities at Looe Key were in the summer of 1998, however, this was the result of a large scale freshwater source from the G.O.M. (Mississippi River) affecting the entire Southwest Florida Shelf.



No High Nitrogen "Signal" at Looe Key Reef

(J. Boyer data)



- Lapointe 1997 cited N enrichment as major cause for coral decline in Discovery Bay, Jamaica... critiqued by Hughes et al. 1999
- ... suggested that Lapointe's results were consistent with reduced herbivory & elevated SST...
- Coral Reef at Discovery Bay has since recovered significantly without any effort to reduce nutrient loading discounting Lapointe's hypothesis (Woodley 1999, Aronson and Precht 2000, Edmunds and Carpenter 2001, Szmant 2002)

The Looe Key Coral Bleaching of 1997-1998 was almost certainly the result of high SST and high UV penetration, not increased nitrogen derived from freshwater discharge

